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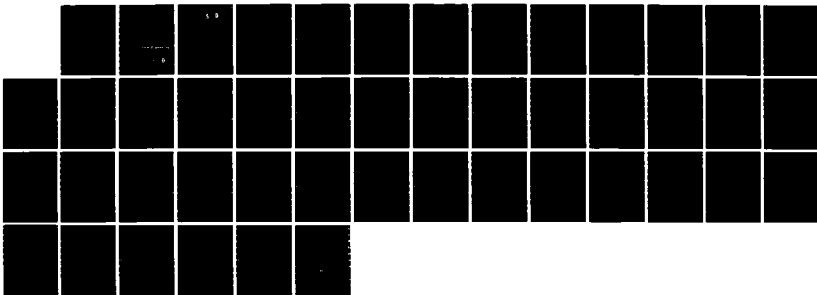
RECOMPRESSION FACILITIES PREFERRED DESIGN AND
CONSTRUCTION PRACTICES(U) NAVAL FACILITIES ENGINEERING
COMMAND WASHINGTON DC CHESAPEAKE DIV 14 JUL 82
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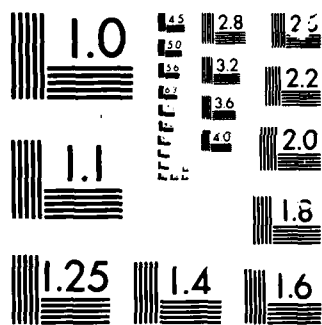
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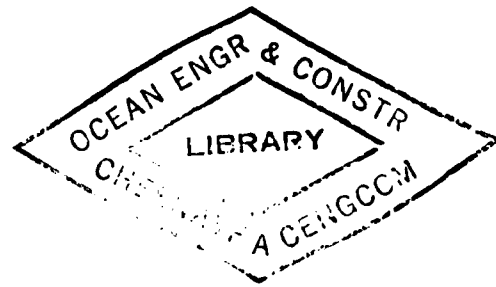
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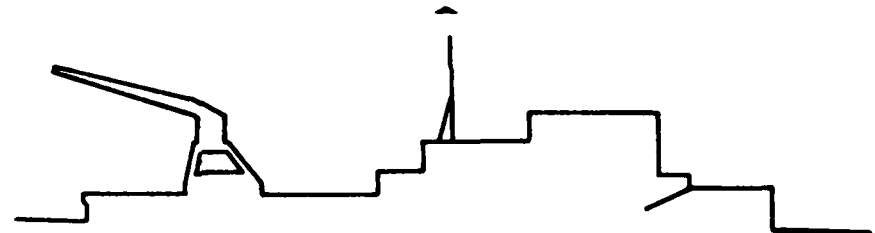
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Recompression Facilities

Preferred
Design & Construction
Practices

FPO-1-82(10)



Ocean Engineering

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

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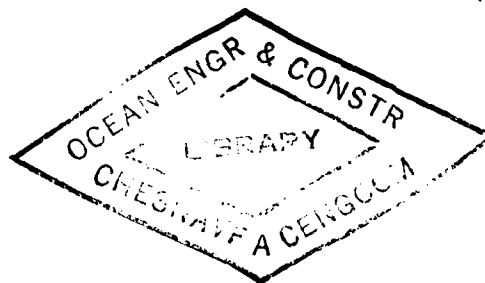
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Recompression Facilities

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DISTRIBUTION STATEMENT A

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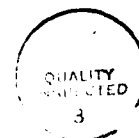
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Section I

General

1. The U.S. Navy's shore establishment includes more than fifty Recompression Facilities (RF). The RFs are used for the treatment of divers that have suffered an accident resulting in the bends, embolism or other medical problems. The U.S. Navy Diving Manual, change 2, dated June 1978 contains diving profiles for the treatment of these medical problems. In addition some design criteria are cited for the RFs.
2. CHESNAVFACENGCOM is tasked to provide the design, construction and facilities management of shore-based Hyperbaric Facilities of which RFs are a part. This document contains a summation of preferred practices in the design and construction of RFs. The cited practices are a product of CHESNAVFACENGCOM experience in the design and construction of many types of hyperbaric facilities. The recommended schematics, materials and construction methods are among many that are acceptable and certifiable. These practices however, constitute good advice that is the product of many "lessons learned".
3. RFs are composed of chambers, piping, communications, lighting and electrical power systems. As of this writing, piping systems for currently existing U.S. Navy standard two lock aluminum and steel chambers are discussed. Subsequent issues of this document will contain communication, lighting and electrical power systems data.
4. The technical data in this report conforms to the treatment tables and technical requirements of the Diving Manual as a minimum. All characteristics cited are calculated to provide RFs that can perform the treatment tables. Further, the systems described herein are designed for fail-safe operation, that is, the failure of a system to function that results in risk to the chamber occupant is backed up by a totally independent capability. These guidelines are written in view of the fact that a majority of this type of work is accomplished by commercial contracts. Therefore, commercial standards (ie., ANSI B31.1) are cited rather than Military Standards.

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Section II

SYSTEM OPERATIONAL REQUIREMENTS

U.S. NAVY - STANDARD TWO LOCK ALUMINUM
RECOMPRESSION CHAMBER

NSN 2H-4220-00-540-2785

Developed in accordance with the U.S. Navy Diving Manual Change 2 dtd June 1978.

A. RECOMPRESSION CHAMBER

a. Maximum Allowable Working Pressure: 100 psig
b. Volume
1. Inner Lock: 136 ft ³
2. Outer Lock: 65 ft ³
c. Depth: 0-225 fsw
d. Dive Rates
1. Inner Lock: 60 fsw/min @ 165 fsw; 25 fsw/min @ 165 fsw
2. Outer Lock: 165 fsw/min @ 165 fsw
e. Ascent Rates
1. Inner Lock: 26 fsw/min @ 60 fsw; 10 fsw/min @ 10 fsw; 1 fsw/min @ 10 fsw
2. Outer Lock: 60 fsw/min @ 10 fsw
f. Ventilation Rate (either lock): 70 scf/min.

B. HIGH PRESSURE AIR SYSTEM

a. Maximum Operating Pressure: 3000 psig
b. Minimum Operating Pressure: 1000 psig
c. Maximum Operating Flow Rate: 365 scf/min.
d. Storage Capacity
1. Primary: 3012 scf
2. Secondary: 3501 scf

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e. Storage Recharge Rate: (primary storage) 3 hours

f. Suggested Pipe Size: 1" NPS (Nominal Pipe Size)
--

C . LOW PRESSURE AIR SYSTEM

a. Maximum Operating Pressure: 350 psig

b. Minimum Operating Pressure: 250 psig

c. Maximum Operating Flow Rate: 365 scf/min.
--

d. Volume Tank Capacity: 16 ft ³ , water volume
--

e. Suggested Pipe Sizes (up to 100' length)

1. Pressurization (both locks): 1" NPS
--

2. Inner Lock Vent: 1 1/4" NPS

3. Outer Lock Vent: 2" NPS

f. Air Flow LP Air Compressor: 70 scf/min.
--

g. Air Temperature LP Air Compressor: 90°F maximum
--

D . OXYGEN SYSTEM

a. Maximum Storage Pressure : 3000 psig

b. Minimum Storage Pressure : 1000 psig

c. Low Pressure: 350 psig

d. Storage Capacity: 1038 scf

e. Supply Flow Rate : 21.7 scf/min.

f. Vent Flow Rate : 22 scf/min. using overboard dump. 180 scf/min. interrupted vent. No dump.

Section II

SYSTEM OPERATIONAL REQUIREMENTS

STANDARD NAVY TWO LOCK
STEEL RECOMPRESSION CHAMBER

NSN 2H-4220-00-368-3346

The data listed is in accordance with the U.S. Navy Dive Manual Change 2 dtd June 1978.

A. RECOMPRESSION CHAMBER

a. Maximum Allowable Working Pressure :	200 psig
b. Volume	
1. Inner Lock :	335 ft ³
2. Outer Lock :	147 ft ³
c. Depth:	0-450 fsw
d. Dive Rates	
1. Inner Lock:	60 fsw/min @ 165 fsw; 25 fsw/min @ 165 fsw
2. Outer Lock:	165 fsw/min @ 165 fsw
e. Ascent Rates	
1. Inner Lock:	26 fsw/min @ 60 fsw; 10 fsw/min @ 10 fsw; 1 fsw/min @ 10 fsw
2. Outer Lock:	60 fsw/min @ 10 fsw
f. Ventilation Rate (either lock):	70 scf/min.

B. HIGH PRESSURE AIR SYSTEM

a. Maximum Operating Pressure :	3000 psig
b. Minimum Operating Pressure :	1000 psig
c. Maximum Operating Flow Rate :	875 scf/min.
d. Storage Capacity	
1. Primary :	6624 scf
2. Secondary :	8225 scf

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e. Storage Recharge Rate: (Primary storage) 3 hours

f. Suggested Pipe Size: 1 1/4" NPS (Nominal Pipe Size)
--

C . LOW PRESSURE AIR SYSTEM

a. Maximum Operating Pressure: 450 psig

b. Minimum Operating Pressure: 350 psig

c. Maximum Operating Flow Rate: 803 scf/min.
--

d. Volume Tank Capacity: 16 ft ³ , water volume
--

e. Suggested Pipe Sizes (up to 100' length)

1. Pressurization (both locks): 1 1/4" NPS
--

2. Inner Lock Vent: 2" NPS

3. Outer Lock Vent: 2 1/2" NPS

f. Air Flow LP Air Compressor: 70 scf/min.
--

g. Air Temperature LP Air Compressor: 90°F
--

D. OXYGEN SYSTEM

a. Maximum Storage Pressure: 3000 psig
--

b. Minimum Storage Pressure: 1000 psig
--

c. Low Pressure: 350 psig

d. Storage Capacity: 2500 psig

e. Supply Flow Rate: 21.7 scf/min.

f. Vent Flow Rate: 23 scf/min. with overboard dump. 182 scf/min. interrupted vent. No dump system.
--

Section III

System Operational Description

1. AIR PRESSURIZATION SYSTEM (APS):

1.1 The recompression chamber is pressurized and ventilated by means of the APS. The APS consists of high pressure and low pressure air systems with compression, storage and distribution capability.

1.1.1 The High Pressure Air System (compressors, filters, moisture separator, etc.) consists of primary and secondary subsystems that are totally independent of each other. Both systems are to be charged to maximum operating pressure prior to commencing a dive.

1.1.1.1 Primary high pressure air system is for the initial pressurization of the chamber. The storage volume, component and piping sizes are calculated to meet required pressurization rates and frequency. Once the chamber has been pressurized, a brief period of ventilation (approximately 2 minutes), while maintaining depth, is accomplished to reduce heat in the chamber due to compression. The primary system is then secured until needed for additional compressions such as; excursions of the outer lock to relieve attendants or repressurization of the chamber.

1.1.1.2 Secondary (Stand-by) high pressure air system is for the purpose of supplying emergency back-up air should component/system failure occur or the need of an emergency breathing air source become necessary. The secondary system is totally independent of the primary system; failure or contamination of the primary system will not impact the operability of the secondary system. The system contains sufficient stored air to conduct the first 30 minutes of a table 6A including two outer chamber "elevator" dives to 165 fsw. The secondary system shall be charged, and a certified air analysis made. The system shall not be used until an emergency arises.

1.1.2 Low pressure air system (compressor, coolers, filters, moisture separators, purifiers and volume tank) is a source of air for ventilation as required to reduce CO_2 and O_2 (if overboard dump not in use) build up in the chamber. The low pressure air supply is put on line after pressurization, then used during the decompression schedule.

2. VENT SYSTEM:

2.1. The vent system is the means of exhausting gases out of the chamber, away from manned operating areas. In doing so, the vent system is required to control two functions.

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2.1.1 Control of Ascent Rates. The vent system valving is capable of accurately controlling all required ascent rates at respective depths.

2.1.2 The vent system, by means of the flow meter and necessary valving is capable of controlling and gauging the required ventilation rates at various decompression stops in order to prevent CO_2/O_2 build-up.

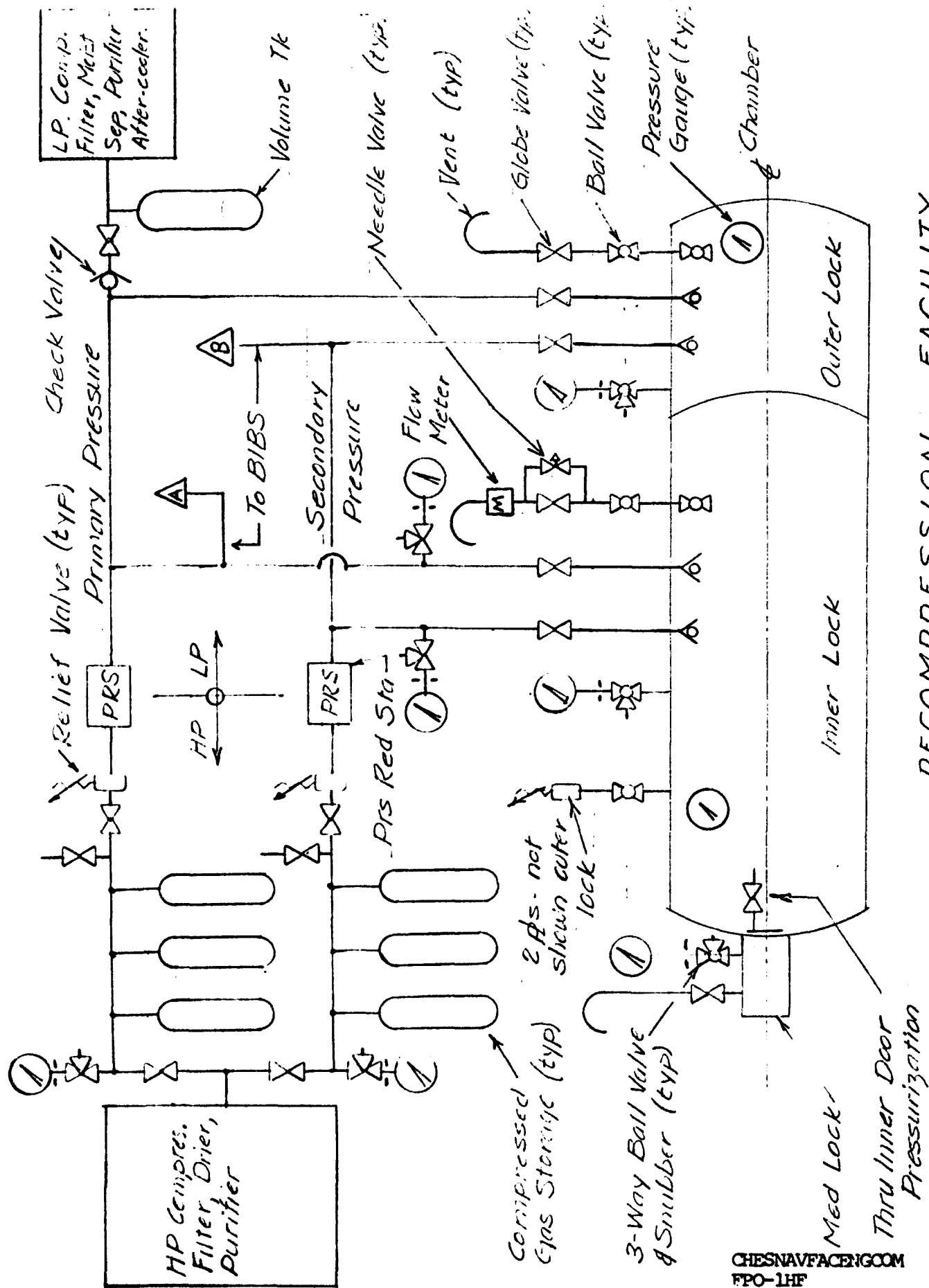
3. BUILT-IN BREATHING SYSTEM (BIBS):

3.1 Oxygen is supplied by means of replacable oxygen cylinders. The oxygen cylinders may be interchanged during operation. The hand loaded regulator in the reduction station is set at a predetermined pressure, i.e., 350 psig. As part of the mask assembly, there is an adjustable demand regulator capable of reducing the pressure from the reduction station to approximately 50 psig, (or as specified by manufacturer of the particular mask) and maintaining the pressure differential throughout the operating range of the chamber.

3.2 Air from the primary air pressurization system is tied into the BIBS to provide breathing air to the masks in case of contaminated chamber atmosphere. The secondary air system is tied to the masks in the event the primary fails to function. A block and bleed system is in-line to prevent leakage of oxygen into the system while breathing air. When air is needed, the block valves are closed and the vent valve open to allow any "leaked" O_2 to vent to atmosphere, the air is then put on-line to the masks.

3.3 A negative biased back pressure regulator is in-line in the overboard dump subsystem. Its function is to control the differential pressure between the mask and outside atmosphere. This allows the occupant to exhale "overboard". The exhaust system is isolated from other chamber exhausts.

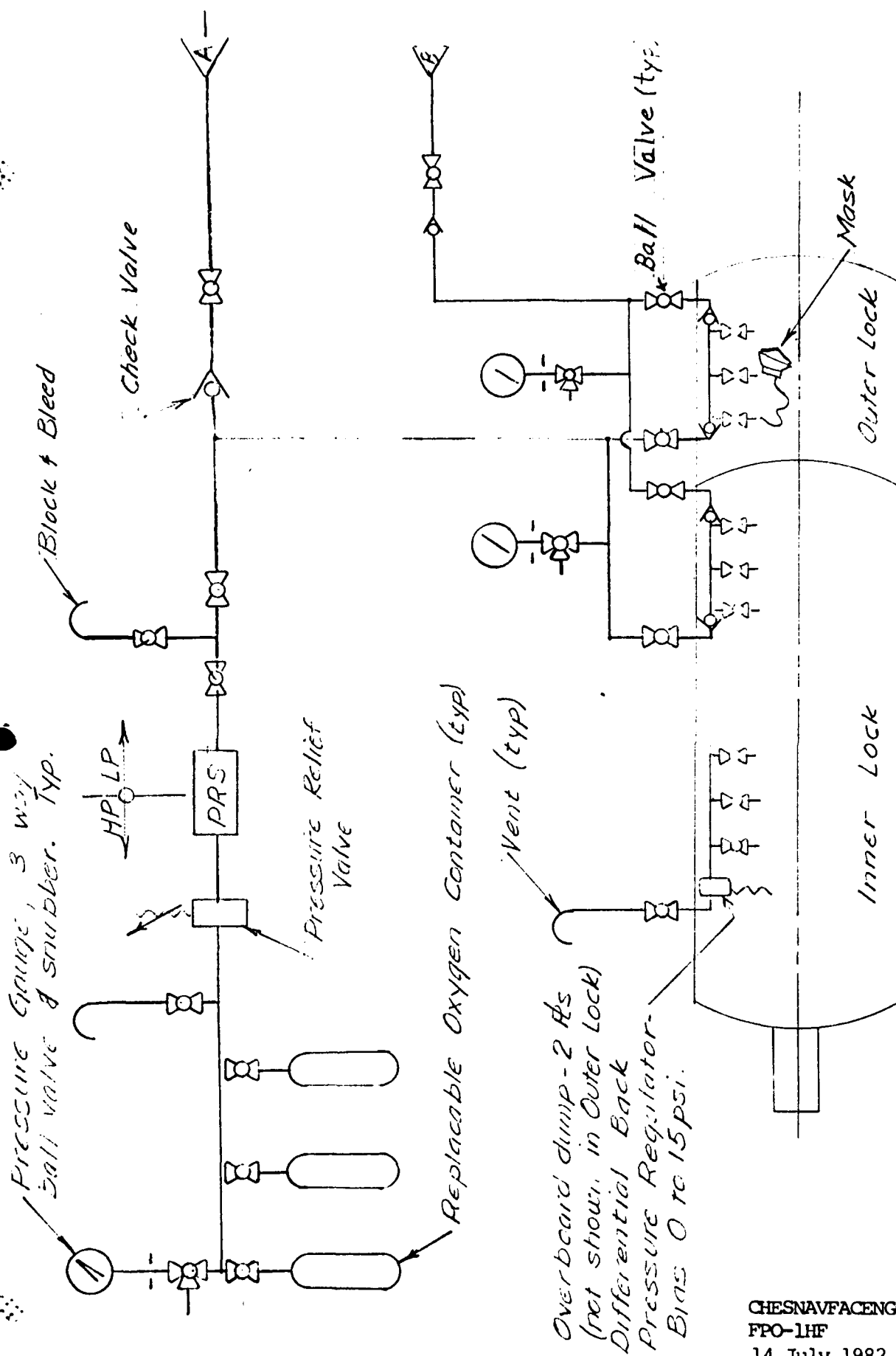
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RECOMPRESSION FACILITY Air Pressurization & Vent System

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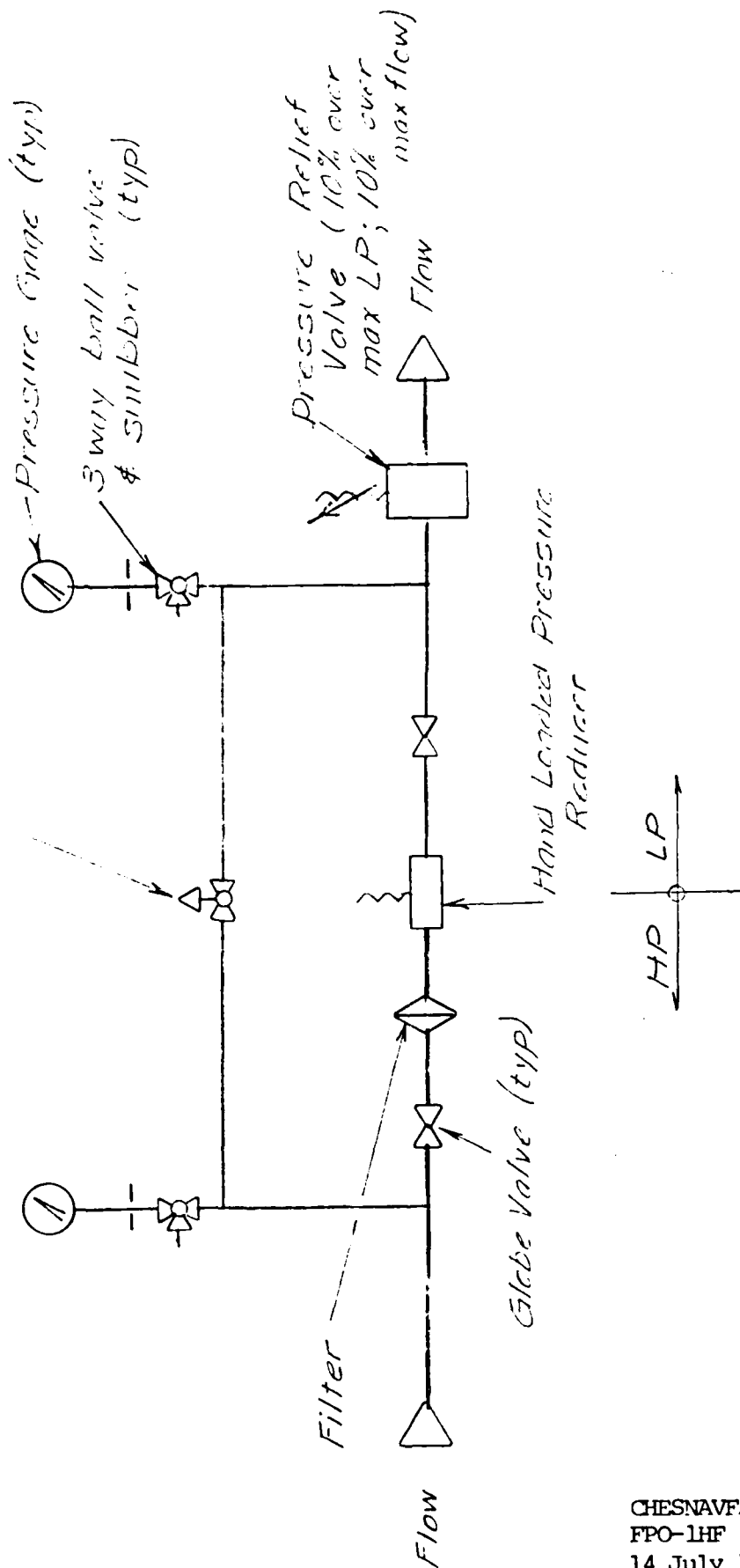


RECOMPRESSION FACILITY
Built-in-Breathing System

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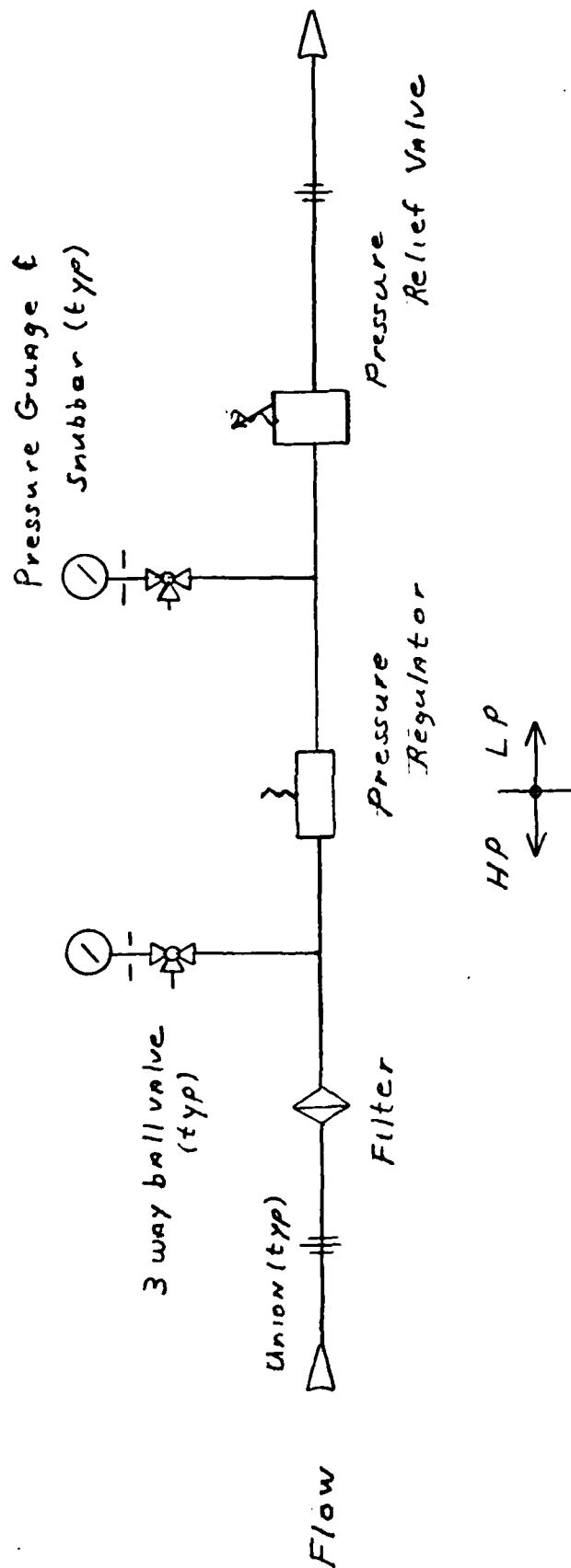
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Needle Valve



PRESSURE REDUCTION STATION BIBS

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PRESSURE REDUCTION STATION AIR SYSTEM

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Section IV

Piping Design, Construction, Cleaning and Inspection Guidelines

(Note: This section is in specification format)

1. DESIGN GUIDELINES: Components and piping shall be selected to conform to the pressure requirements of ANSI B31.1 and for service, at the pressure, temperature and flow indicated in Section II, System Operational Requirements. The acceptability of pressure containing components is based upon ANSI B31.1, paragraph 104.7, "Pressure Design of other Pressure Containing Components". The following extract from the paragraph is the basis of judgement "... Pressure containing components not covered by the standards listed in Table 126.1 and for which design formulas or procedures are not given in this code, may be used where the design of similarly, proportioned and sized components has been proven satisfactory by successful performance under comparable service conditions..." In addition, components shall be those used in the diving industry; if not, submittals will be rejected.

1.1 Material and equipment installed in the piping systems shall be suitable for the gases and liquids contained and for the maximum operating temperature and pressures. All valves shall be placed so they can be easily reached and operated by a man without the aid of special equipment, such as a ladder, or provide other means of remote mechanical operation. Piping and tubing shall be protected from abuse and accidents and be placed for ease of operation, maintenance and replacement. All gauges and indicators shall be located for ease of reading and operating.

1.2 Connections to Equipment: The supply line to each major piece of equipment shall be equipped with a cut-off valve and union to enable isolation of the equipment for repair and maintenance without interfering with the operation of other equipment. A length of flexible hose shall be used in connections to reciprocating machinery.

1.3 Protection to Materials and Equipment: Pipe openings shall be closed with caps or plugs during installation. Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury.

1.4 Piping shall not run through nor encroach on the areas designated as passage ways or working areas and shall run only within the envelopes provided.

1.5 All piping shall be 1/2" NPs or larger. Piping unless otherwise specified shall be seamless annealed stainless steel conforming to ASTM A312 Type 304L or 316L.

1.6 All tubing shall be 3/8" or larger. Tubing unless otherwise specified shall be seamless annealed stainless steel conforming to ASTM A269 Type 304L or 316L.

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1.7 Flexible hoses shall have a minimum working pressure of two times the system operating pressure and minimum burst pressure of three times the system operating pressure.

1.8 Pressurization piping shall be sized so that maximum gas velocity is .8 mach. "Flexible" inserts in piping shall exist between the chamber hull and the throttling valve.

1.9 All components in the oxygen system shall conform to Compressed Gas Association (CGA) pamphlet G-4.4, "Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems".

1.9.1 Breathing gas components shall have seats and seals that are suitable for oxygen service.

1.9.2 All lubricants shall be suitable for oxygen service.

1.9.3 Components specified as compatible with oxygen shall not react with oxygen or fluorinated compounds in any way that might cause generation of heat or the loss of oxygen to the surrounding atmosphere. Such components shall utilize tetrafluorethylene, polychlorotrifluorethylene or vinylidene fluoride hexafluoropropylene seals and gaskets. All other wetted parts shall be stainless steel unless otherwise approved.

1.9.4 All O₂ piping shall be grounded.

1.10 Check Valves: All check valves shall utilize a soft sealing surface poppet or disc and spring.

1.11 Relief Valves: All relief valves shall utilize a soft sealing surface and be compatible with air and oxygen. The components material shall be brass or stainless steel. All relief valves shall be rated at a pressure and flow rating of 10% over maximum operating conditions of the component or piping system which the relief valve is installed. Relief valves shall be located so that the relief valve is no closer than 5 feet from the operators. Relief valves for all O₂ piping and for others greater than 1" shall be piped to the outdoors. Relief valves on manned chambers shall conform to and be marked and stamped in accordance with ASME Section VIII, Division 2; and they shall be sized so that when open the rate of chamber depressurization shall be less than 60 feet of sea water per minute. All others shall conform to and be marked and stamped in accordance with ASME Section VIII, Division 1.

1.12 Moisture Separator: The moisture separator(s) shall be capable of removing the element without disassembling the body from the piping. The moisture separator(s) shall be capable of reducing the dewpoint of compressed air to a -40°F.

1.13 Filters: All filters shall be capable of having the filter element replaced without removing solid contaminants to a particle size of 15 microns nominal.

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1.14 Pressure Gauges: Pressure gauges, except as otherwise specified, shall be 4 1/2 inch dial with phosphor bronze, 304 or 316 stainless steel helical bourdon coil or tube. The case shall be made of acrylonitrile butadiene styrene plastic and shall have a blowout relief device. The dial shall be at least 30 percent but not more than 75 percent greater than the maximum working pressure of the line in which the gauge is installed. Oxygen gauges shall be cleaned and marked for oxygen service.

1.14.1 Provide a pressure gauge for each lock externally mounted to monitor chamber pressure, they shall have an 8 1/2" dial and shall be calibrated in feet of seawater (fsw). The gauges shall have a maximum pressure of 250 fsw and shall have an accuracy of plus or minus 1/4 of 1 percent. The smallest graduations shall be 2 fsw with numerical indication at 10 fsw graduations.

1.14.2 Provide a pressure gauge for each lock mounted inside the chamber to monitor chamber pressure. They shall be caisson gauges with a 6" dial calibrated in feet of seawater (fsw). The gauges shall have a maximum pressure of 250 fsw and shall have an accuracy of plus or minus 1/4 of 1 percent. The smallest graduations shall be 2 fsw with numerical indications at 10 fsw graduations. They shall be mounted so that they may be seen by the outside operators.

1.14.3 The total range percentage of accuracy of a gauge shall be numerically less than:

$$P = \frac{100 DE - 2P}{DP}$$

where:

P = total percentage accuracy (sometimes cited as say 1% or 1/2% which are equal values for this purpose).

D = diameter of arc on which graduation are located.

P = maximum operating pressure (psi) or depth (fsw).

E = desired reading error (psi) or depth (fsw).

1.15 Pressure Reduction Station: Provide each pressure reducing station with a regulator, a strainer in the entering line, two blocking valves and a globe or angle bypass valve. Size the bypass valve to restrict its

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capacity to approximately that of the reducing valve. Provide each pressure reducing station with an indicating gauge to show the reduced pressure and a safety valve on the low pressure side with sufficient capacity to relieve the high pressure. The components shall be selected so that the downstream pressure is within the maximum and minimum pressures cited in the "System Operational Requirements" for all conditions of flow and upstream pressure.

1.16 Throttle Valves: The contractor shall submit to the Government the throttle valve manufacturer's "Cv vs. Number of Turns of Valve Handle" curve. The "Cv vs. Turns" curve shall be a straight line over the full range of Cv valves required. The slope of the "Cv vs. Turns" curve shall be such that the Cv set point $\pm 2\%$ at any point within the Cv range may be set within no more than 20° of valve handle turn nor less than 5° of valve handle turn.

1.17 Low Pressure Air Compressor: The compressor type with it's lubricant shall be approved for breathing air service. On the discharge side of the volume tank, there shall be a filter assembly capable of maintaining air quality in accordance with (CGA Spec. G-7). The compressor package shall be mounted on a frame isolated from the main equipment frame. The air intake shall be piped from a location outside of the building.

1.18 Volume Tank: The air volume tank shall be built to ASME₃ Section VIII, Division 1. The tank shall have a minimum capacity of 16 ft.³ or approximately 120 gallons. The design working pressure shall be 250 psig.

1.19 High Pressure Air Compressor(s): The HP air compressor shall have an electric motor that is 3 phase dual voltage rated for continuous service as prime mover. The discharge of the compressor shall have a moisture trap/filter assembly capable of maintaining air quality in accordance with CGA-7. The dewpoint of compressed air to storage shall not exceed -40°F. The HP air compressor(s) shall have the capability of recharging the HP air bank in no more than 3 hours. The air intake shall be piped from a location outside of the building.

1.20 Provide a built-in breathing system (BIBS) for oxygen treatment and emergency air. There shall be four oral-nasal type masks in the main lock and four oral-nasal masks in the outer lock. The exhaust of the masks shall discharge to the outside the building atmosphere with the aid of a negative bias back pressure regulator.

1.21 Each vent line (i.e., BIBS exhaust, inner lock vent, outer lock vent) shall be dedicated to its respective system and piped to discharge outside of the recompression chamber facility building. Vent lines shall be provided with lightning protection.

1.22 All vents and relief valve penetrations internal to the chambers shall be arranged so that items will not be ingested into the line.

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1.23 All powered hull valves shall be "fail-closed".

2. CONSTRUCTION GUIDELINES:

2.1 Installation shall conform to the requirements of ANSI B31.1.

2.2 Cutting and Repairing: The new work shall be carefully laid out in advance, and no excessive cutting of construction will be permitted.

2.3 Piping shall not run through nor encroach on the areas designated as passage ways or working areas. Shop drawings shall clearly indicate operating areas and maintenance areas.

2.4 Joints shall be butt weld, socket weld or flanged fitting. Threaded O-ring faced fittings may be used. Bite type fittings shall not be used. Brazed joints shall not be used. Threaded joints shall not be used. Oxygen piping shall be butt welded or suitable flanged joints may be used.

2.5 All tubing of a given diameter shall have the same wall thickness.

2.6 Unions and/or flanged fittings shall be placed so that the piping may be readily disassembled for maintenance purposes.

2.7 All valves shall be placed so that they may be easily reached and operated without the need of special equipment such as ladders, reach rods, etc. Gauges related to the operation of valves shall be efficiently located with respect to the valve.

2.8 Piping and tubing shall be protected from abuse and accidents and be placed for the ease of operation and maintenance. Horizontal runs shall be supported at intervals not to exceed 100 pipe (or tube) diameters; vertical runs shall be supported at intervals not to exceed 300 pipe diameters. There shall be support in both directions at elbows.

2.9 Identification of Piping: Identify in accordance with MILSTD 101, using adhesive backed or snap-on labels and arrows. Apply to finished paint or insulation at intervals of not more than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

2.10 Valves and components on lines shall be independently supported. In no case shall the force required to operate a component cause a deflection in excess of 1/32 inch.

2.11 All welding shall conform to the requirements of ANSI B31.1, which in turn specifies ASME Section IX, "Welding and Brazing Qualification". The contractor shall submit copies of the following prior to conducting welding.

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2.11.1 "Procedure Specification", Form #QW482.

2.11.2 "Manufacturer's Record of Welder or Welding Operator Qualifications Tests", Form #QW484. All welders and welding operators shall be qualified by the contractor. Qualification forms #QW484 from previous employers of welder and welding operators is not acceptable. (See ANSI B31.1, paragraph 127.5.3(B)).

2.12 To facilitate cleaning and hydro-testing, each piping high point shall contain a vent, horizontal runs shall slope 1/16 inch per foot, trap and drain shall be at each low point.

2.13 Fabricated tees, elbows and branches shall not be used.

3. CLEANING GUIDELINES:

3.1 General: The contractor shall be responsible to clean piping and components as specified hereinafter. Equipment, materials, instruments, personnel and laboratory services required for cleaning and certification shall be provided by the contractor. Components which are certified clean upon delivery by the manufacturer will not require cleaning if the integrity is not violated. Components which have been shop tested and certified for cleanliness shall be isolated from the system during cleaning operations. Systems may be cleaned as a whole or in sections providing all clean piping is kept isolated and free of contamination while cleaning associated piping.

3.2 Cleaning Procedure: The contractor shall submit his cleaning procedure to the Contracting Officer for review. He shall prepare a sample of his constructed piping, which shall include fittings, clean it in accordance with his submitted procedures, test a gas sample, and show that analysis confirms the gas meets the acceptance standards outlined in paragraph 3.4.

3.3 Gas piping and tubing which have been certified clean by analysis of the gas sample shall be sealed and kept free of contamination until final acceptance of the system. After certification, lines shall be broken only for the length of time required to install components. Such components shall also be certified clean.

3.4 Gas Sample Analysis: After cleaning, hydrotesting and assembly, a gas sample shall be taken from each system that contains gases that will be breathed by humans and analyzed for trace contaminants. Trace contaminants and their maximum limits shall be in accordance with the following table or "Limits for Atmospheric Constituents, 90 Day Limit", Appendix E, Breathing Gas Requirements NAVMAT P-9290.

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MAXIMUM CONCENTRATION OF SOME COMMON CONTAMINENTS

IN HYPERBARIC FACILITIES

(Surface Equivalent Values)

Carbon Dioxide	1000 ppm (3.8mmHg) (.001ATA)
Carbon Monoxide	10 ppm
Methane	1000 ppm
Methanol	200 ppm
Total Hydrocarbons (less Methane)	10 ppm
Benzene	1 ppm
Halogenated Hydrocarbons	1 ppm
Oil Mist plus Particulate Matter	5 mg/m ³

PROHIBITIONS: The use of an organic solvent as a cleaning agent is prohibited (typical: petroleum solvents, chlorinated hydrocarbons).

4. INSPECTION GUIDELINES:

4.1 General: The contractor shall perform all examinations, inspections, and tests in conformance with ANSI B31.1; he shall complete and submit all records that are required thereby. The contractor shall notify the Contracting Officer at least 5 days in advance of all tests. Tests shall be conducted in the presence of the Contracting Officer or his duly authorized representative.

4.2 Equipment, materials, instruments and personnel required for the examination, inspection and tests shall be furnished by the contractor. All recording instruments and gauges used shall be calibrated and certified accurate by an independent laboratory normally engaged in this type work within 30 days prior to the test.

4.3 Test procedures and schedules shall be prepared by the contractor and submitted for approval by the Contracting Officer. The procedure and schedules shall be sufficiently detailed to permit evaluation of their completeness and sufficiency.

4.4 Test records and reports. All test records shall be of a permanent nature such as strip charts, disc charts or log forms. Test reports shall be furnished to the Contracting Officer before acceptance.

4.5 Examination of pressure welds and welds to Pressure Retaining Components shall conform to the following, and shall supercede the provisions of ANSI B31.1, Table 136.4, "Mandatory Minimum Non-Destructive Examinations for Pressure Welds or Welds to Pressure Retaining Components".

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<u>Weld Type</u>	<u>Non-Destructive Examination</u>
Buttwelds (Girth and Longitudinal)	RT
Welded Branch Connections	RT for NPS over 2 inches, MT or PT for NPS 2 inches and less
Fillet, Socket Welds	PT or MT all sizes and thickness

NOTES:

1) All welds must be given a visual examination in addition to the type of specific non-destructive examination specified. Acceptance standards are those of American Welding Society. D1.1, paragraph 8.15.1, "Quality of Welds".

- 2) NPS - Nominal Pipe Size
- 3) RT - Radiographic Examination (see ANSI B31.1, paragraph 136.4.5)
- 4) PT - Liquid Penetrant Examination (see ANSI B31.1, paragraph 136.4.4)
- 5) MT - Magnetic Partial Examination (see ANSI B31.1, paragraph 136.4.3)

4.6 Piping shall be leak tested in conformance with ANSI B31.1, paragraph 137, "Leak Tests". Piping shall be subjected to "Hydrostatic Leak Tests" (ANSI B31.1, paragraph 137.3) and "Pneumatic Leak Tests" (ANSI B31.1 paragraph 137.4).

4.7 Leak Testing: All electrical penetrators shall be bubble tested to system rated pressure, 100 psig. Acceptance criteria shall be no bubbles evident. During hydrostatic test, the maximum test pressure shall be 1 1/2 design pressure or a pressure that is calculated to produce a hoop stress in the pipe equal to S_m , whichever is greatest.

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Section V
Qualification for Use of Existing Equipment

Economies are often available in the use of existing equipment in the construction of Hyperbaric Facilities. Existing pressure chambers, atmosphere conditioning systems etc. that are available should be employed where applicable. It is incumbent upon the Project Management to assure that equipment meets current safety quality standards. It is mandatory that systems engineered in say, 1982 meet 1982 standards. It is irrational to accept an existing chamber built and conforming to 1953 standards, to save money as it is to build a new chamber in 1982 to 1953 standards to save money.

Therefore, in order to assure conformance to appropriate standards, the following shall be done. These items follow the outline of inspection for new chambers as cited in ASME Section VIII, Division 1; modified to accommodate existing equipment.

- Determine if chamber was ASME stamped; if so get copy to "Data Report".
- Get copies of as-built drawings and calculations. Compare to chamber to determine if uncontrolled field changes have been made; if so determine a course of action. Update drawings and calculations.
- Obtain mill certs or sample material - exercise caution with field modifications.
- Visual Examination
 - Note negative effects of corrosion, abuse and aging.
 - Assure that viewports, gaskets, seals, threads are adequate.
 - UT hull in areas of corrosion; thickness must be within nominal plate tolerance.
- Weld Quality
 - Obtain weld procedure and welder qualifications if not available take sample - test to ASME standards.
- NDT Grind all Welds
 - Radiograph all butt welds.
 - Dye Pen all corner welds inside and outside.
- Hydrotest

The decision tree on the following page will aide in making a decision consistent with requirements.



Section VI

CHESNAVFACENGCOM
Ocean Engineering & Construction Project Office
Hyperbaric Facilities Division

ASME New Pressure Vessel
Quality Assurance
Check-off List

- _____
- _____
- _____
1. Manufacturers Certificate of Authorization:
_____, expiration date _____
 2. User's Design Specification: _____
Certification by Registered Professional Engineer;
Name _____, State _____, No. _____
 3. Manufacturer's Design Report _____
Certification by Registered Professional Engineer;
Name _____, State _____, No. _____
 4. Drawings; # _____ are available.
Welds conform to PMIO-1? _____
 5. Calculations; _____ are available.
 6. Partial Data Reports;

QA Engineer Signature _____ Date _____
Pressure Vessel Serial # _____

7. Materials

- a. Mill Certifications _____
- b. Inspection Records _____
 - (1) Pre-fabrication:
 - o Thickness _____
 - o Defects _____
 - o Allowed Material _____
 - o Traceability _____
 - o Impact Tests (per PVHO-1) _____
 - o Shells, Heads within tolerance _____
- c. QA Inspection _____
 - (1) Materials conform to certs. _____
 - (2) Traceability intact. _____

8. Fabrication

- a. Weld Procedure Qualifications (copies attached) _____
- b. Welder Qualifications (copies attached) _____
- c. Record of pre-welding inspection of prepared and fitted joints. _____
- d. Repair Records _____
- e. Post Weld Heat Treatment Records _____
- f. Non-Destructive Examination (Test report attached)
Any rejectable indications remain? _____
Meet PVHO-1 requirements? _____

9. Hydrostatic Test _____

- a. QA Witness _____
- b. Post Hydrostatic Test Dye Penetration Examination
Report (per PVHO-1) _____

10. Nameplate and Stamp attached to vessel _____

11. Manufacturers Data Report (attached) fully executed. _____

Initial/Date

QA Engineer Signature _____ Date _____

Pressure Vessel Serial # _____

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Ocean Engineering & Construction Project Office
Hyperbaric Facilities Division

Piping Systems
Quality Assurance
Check-off List

	Initial/Date
1. User's Design Specification: _____	_____
2. Manufacturer's Design Report _____	_____
3. Drawings; # _____ are available	_____
4. Calculations; _____ are available	_____
5. Materials	
a. Mill Certifications _____	_____
b. Inspection Records	
(1) Materials conform to certs _____	_____
(2) Traceability intact _____	_____
6. Fabrication	
a. Weld Procedure Qualifications (copies attached) _____	_____
b. Welder Qualifications (copies attached) _____	_____
c. Repair Records _____	_____
d. Post Weld Heat Treatment Records _____	_____
e. Non-Destructive Examination (Test report attached) Any rejectable indications remain? _____	_____
f. Location of piping supports per specification _____	_____
7. Hydrostatic Test _____	_____
a. QA Witness _____	_____
8. Gas Leak Test _____	_____
9. Gas Cleanliness Report _____	_____
10. Calibration Records _____	_____
11. Final Functional Test Report _____	_____
QA Engineer Signature _____	Date _____

Section VIII

Test Dive Scenario

1. Record the following information prior to commencement of test.

- a. Primary air supply water volume
- b. Primary air supply pressure
- c. Secondary air supply water volume
- d. Secondary air supply pressure
- e. Under static conditions, pressure of L.P. side primary pressurization regulator

2. Using primary pressurization system, dive inner lock to 165 fsw. Maintain a descent rate of 60 fsw/min.

- a. Output pressure of primary regulator during dive
- b. Primary air supply pressure after pressurization
- c. Record time/depth at one minute intervals on Figure 1

3. Ventilate inner lock (demonstrating 47 scfm flow rate) for two minutes. Record:

- a. Primary bank pressure

4. Dive outer lock to 160 fsw (do not break seal on inner lock hatch). Maintain a descent rate of 165 fsw min.

- a. Primary bank pressure
- b. Record time/depth at one minute intervals on Figure 3

5. Surface the outer lock maintaining an ascent rate of 60 fsw min. to 10 fsw.

- a. Record time/depth at one minute intervals on Figure 3

6. Surface inner lock from 165 fsw to 60 fsw maintaining 26 fsw/min. ascent rate during excursion. Record time/depth at one minute intervals on Figure 2.

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7. Surface the inner lock from 60 fsw to 10 fsw maintaining 10 fsw/min. ascent rate. Record time/depth at one minute intervals on Figure 2.
8. Dive inner lock to 165 fsw maintaining a descent rate of 25 fsw/min.
- a. Record time/depth at one minute intervals on Figure 1
 - b. Record primary air pressure _____
9. Surface the inner lock from 165 fsw to 60 fsw maintaining an ascent rate of 20 fsw/min.
- a. Record time/depth at one minute intervals on Figure 2
10. Change primary air supply source from H.P. flasks to L.P. air compressor. Ventilate inner lock (demonstrating 70 scfm flow rate) for 2 min.
11. Surface the inner lock from:
- a. 60 fsw to 55 fsw, maintain a 1 fsw/min. ascent rate, record time/depth at one minute intervals on Figure 2
 - b. 55 fsw to 20 fsw at 60 fsw/min.
 - c. 20 fsw to 10 fsw, maintain a 1 fsw min. ascent rate record time/depth at one minute intervals on Figure 2
12. With secondary air supply (flasks fully charged, as noted in 1-D) dive both locks to 165 fsw, then ventilate chamber for 1 hour at 70 scfm. Record.
- a. Time to 165 fsw
 - b. Secondary bank pressure after dive _____
 - c. Secondary bank pressure after ventilation _____
13. With the chamber at the surface, demonstrate O₂ supply to masks in inner and outer locks and the ability to cross over from O₂ supply to secondary air supply.

Witnessed _____

Date _____

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14 July 1982

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Recompression Chamber Facility

Inner Lock

Maximum & Minimum

Descent Rates

(1) 0-165 fsw @ 60 fsw/min. (Table 6a, 3 & 4)

(2) 0-165 fsw @ 25 fsw/min. (Table 5, 6, 1a & 2a)

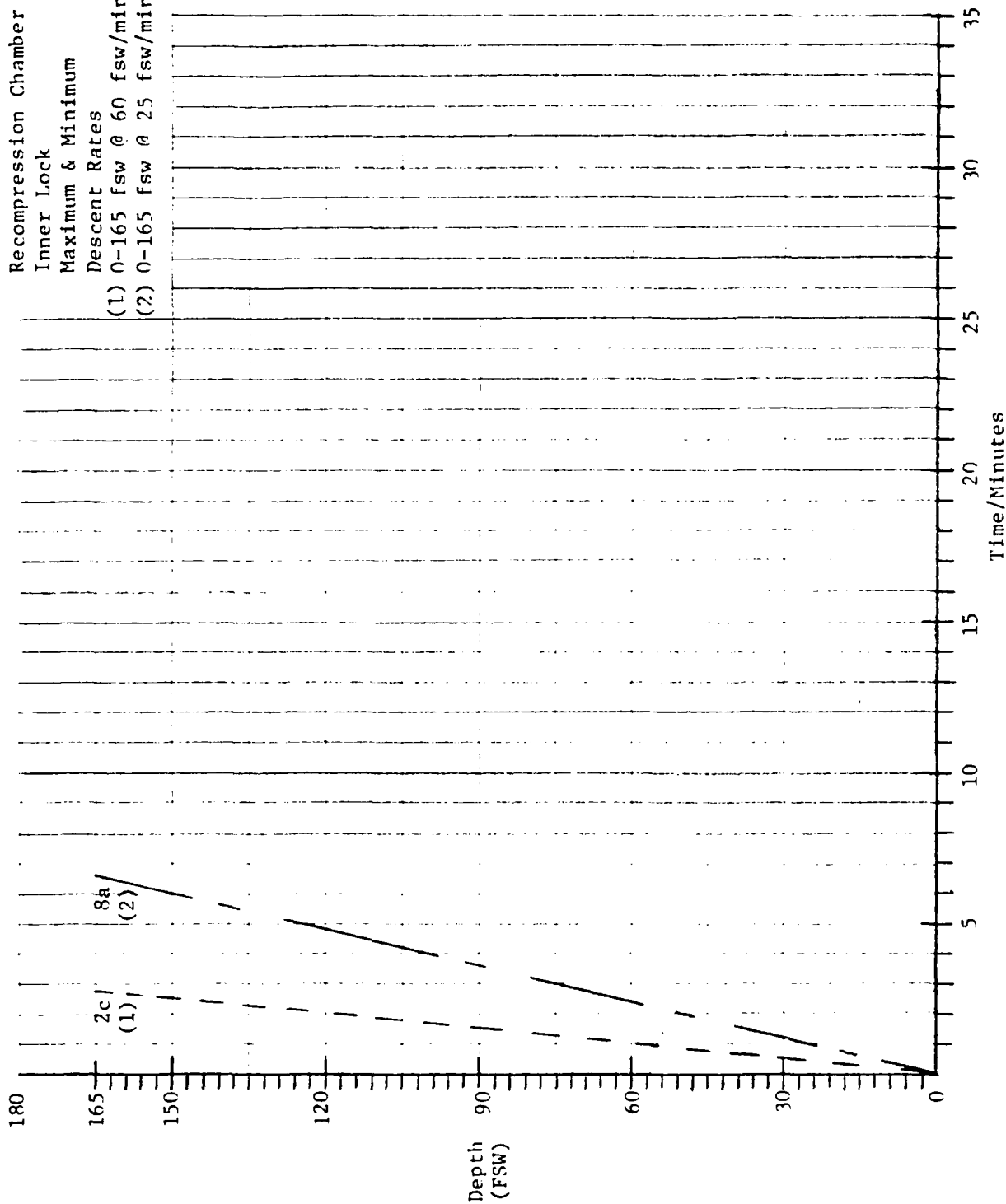


FIGURE 1

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Recompression Chamber Facility

Inner Lock
Maximum & Minimum
Ascent Rates

Treatment
Table

- (1) 165 fsw to 60 fsw @ 26 fsw/min.
(2) 165 fsw to 60 fsw @ 20 fsw/min.
(3) 60 fsw to 10 fsw @ 10 fsw/min.
(4) 60 fsw to 10 fsw @ 1 fsw/min.
- 6a
1a, 2a, 3&4
1a, 2a, 3&4
5, 6&6a

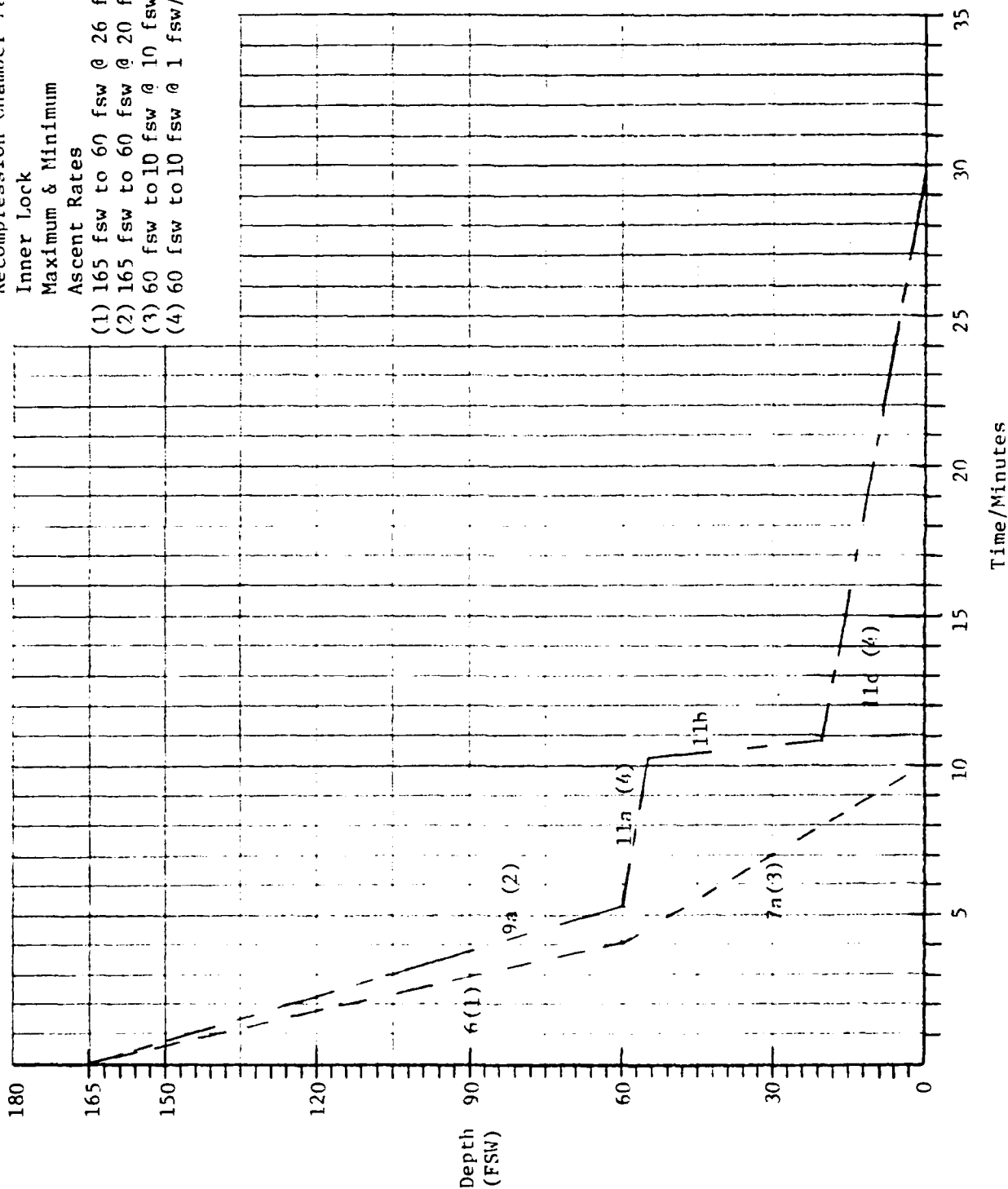


FIGURE 2

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Recompression Chamber Facility
Outer Lock

Ascent & Descent Rates
0-165 fsw @ 165 fsw/min.

165 fsw to 10 fsw @ 60 fsw/min.

NOTE: These rates are required
to transit medical per-
sonnel to and from 165 fsw
without decompression
requirements.

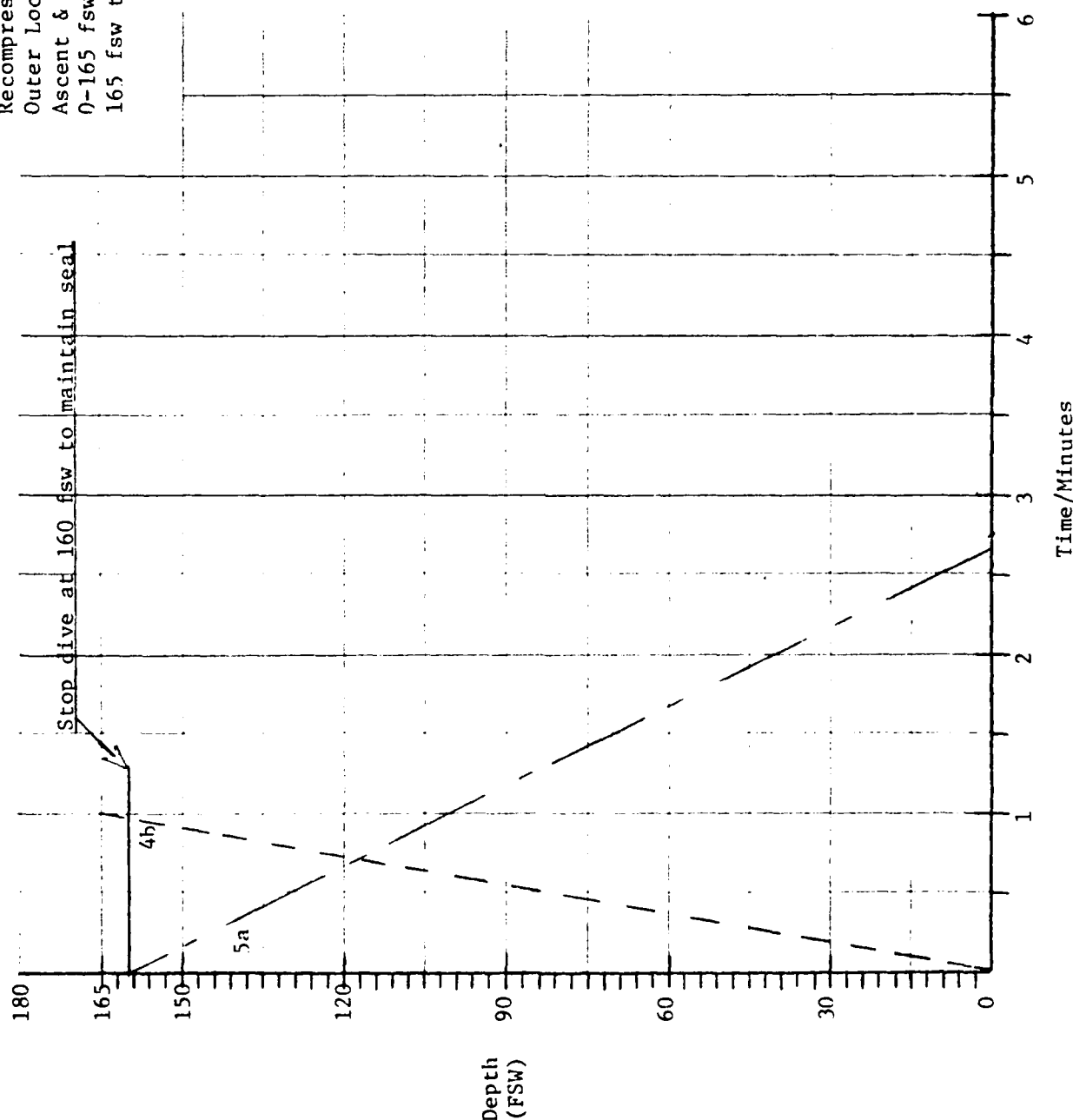


FIGURE 3

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CHESAPEAKE	DIVISION	PROJECT: <u>Resuscitation Chamber</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>LPO LHF</u>	date: <u>2/2/82</u>	Calculations for: <u>U.S.N. 2 Lock</u>
Calcs ck'd by: _____	date: _____	<u>Simulation</u>

1) Volumes

INNER LOCK 136 ft³
 Outer Lock 65 ft³

 Total 201 ft³

2) Performance Requirements

The following dive and ascent rates are taken from "US Navy Divers Handbook". In addition, it is assumed that the outer chamber will be used to transit medical personnel @ 165 fsw/m dive, 60 fsw/m ascent.

Innerlock:

Dive, 60 fsw/m, 0 to 165 fsw
 25 fsw/m, 0 to 165 fsw
 Ascend, 26 fsw/m @ 60 fsw
 10 fsw/m @ 10 fsw
 1 fsw/m @ 10 fsw

Outer Lock:

Dive, 165 fsw/m 0 to 165 fsw
 Ascend, 60 fsw/m 165 fsw to 10 fsw

page ____ of ____

CHESAPEAKE**DIVISION****PROJECT:** _____**Naval Facilities Engineering Command****NDW****Station:** _____**DISCIPLINE****E S R:** _____**Contract:** _____**Calcs made by:** _____**date:** _____**Calculations for:** 2 lock plan**Calcs ck'd by:** _____**date:** _____C) Cont'd

1" (1.049" I.D., $f_t = .023$) 561' MAX length
 3/4" (0.824" I.D., $f_t = .025$) 162' MAX length

Velocity 1" pipe = 901 ft/sec

D) Ascent

Inner lock: Vol. = 136 ft³
 10 fsw/m @ 10' (4.45 psig) (worse condition)

$\Delta P = 4.45$ psi

$P' = 19.15$ psia

$\frac{\Delta P}{P'} = \frac{4.45}{19.15} = 0.23 \therefore Y = 0.90$

USE \rightarrow 1/2" (1.61 I.D., $f_t = .021$) = 831' MAX length
 1/4" (1.38 I.D., $f_t = .022$) = 367' \leftarrow
 1" (1.049 I.D., $f_t = .023$) = 71'

Outer: Vol = 65 ft³
 60 fsw/m @ 10 fsw (4.45 psig)

$\Delta P = 4.45$ psig

$P' = 19.15$ psia

$\frac{\Delta P}{P'} = .23 \therefore Y = 0.90$

USE \rightarrow 2" (2.067 I.D., $f_t = .019$) = 303' MAX length \leftarrow
 1/2" (1.61 I.D., $f_t = .021$) = 50'

page ____ of ____

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CHESAPEAKE**DIVISION****PROJECT:** _____

Naval Facilities Engineering Command

NDW**Station:** _____**DISCIPLINE****E S R:** _____**Contract:** _____

Calcs made by: _____ date: _____

Calculations for: 2 lock repairs

Calcs ck'd by: _____ date: _____

E) Pressure Reduction Station

1) Main Pressurization

Input pressure 3000 psig max, 1000 psig min.

Output pressure 350 psig max, 250 psig min.

$$\text{Max Flow} = 201 \text{ ft}^3 \times 60 \text{ fsw/m} \times \frac{.445}{11.7}$$

$$= 365 \text{ SCFM}$$

F) Air Storage

Note: From "Divers Handbook"; Primary storage sufficient for 2 pressurizations to 165 fsw, ventilation requirements to be handled by LP Compressor. Secondary, sufficient stored air to conduct the first 30 min. of a treatment table GA including, 2 excursions of the outbreath to 165' and 1 charge of inner lock atmosphere no continuous Vent.

Primary 201 ft³ to 165 fsw

$$201 \times 165 \times \frac{.445}{11.7} = 1004 \text{ scf} \times 2 = 2008 \text{ scf}$$

Usable Gas (3000 to 1000 psi)
 \therefore Total stored gas = 3012 scf

page ____ of ____

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CHESAPEAKE	DIVISION	PROJECT: _____
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: _____	date: _____	Calculations for: <u>2 Lock Plum</u>
Calcs ck'd by: _____	date: _____	

F) Corrid

Secondary

Dive Chamber to 165 fsw

$$201 \times 165 \times \frac{.445}{14.7} = 1004 \text{ scf}$$

Two excursions of the outer lock

$$6.5 \times 165 \times \frac{.445}{14.7} \times 2 = 650 \text{ scf}$$

One change of inner lock volume
during first 30 min of 161 GA

$$136 \times 165 \times \frac{.445}{14.7} = 680 \text{ scf}$$

Secondary Volume 2334

Usable Gas 3000 psi to 1000 psi

∴ Total stored gas = 3501 scf

page ____ of ____

CHESAPEAKE	DIVISION	PROJECT: _____
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: _____ date: _____		Calculations for: <u>2 lock 1 door</u>
Calcs ck'd by: _____ date: _____		

Gas Farm Pipe Size - Use 1" to match pressurization lines.

6) O₂ Storage

Adequate from 3000 to 1000 psig to supply one patient thru table six. Assume one patient at rest 1038 SCF O₂.

Supply 6 masks @ 2 acfm @ 60 fsw
 $12 \text{ acfm} \times 60 \times \frac{1.445}{14.7} = 21.7 \text{ SCFM}$

O₂ Reduction Station:

Input pressure, 3000 to 1000 psig

Output 350 psig min

MAX Flow 21.7 SCFM

Use $\frac{3}{8}$ " pipe

Vent Rate, Assume no overboard dump, Interruptal Service

35 acfm @ 60 fsw 150 acfm
 @ 60 fsw 272 SCFM Total
 180 SCFM Innerlock

page ____ of ____

CHESAPEAKE	DIVISION	PROJECT: <u>USN 2 Lock STEEL</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>GIORMAN</u>	date: <u>1/2/82</u>	Calculations for: _____
Calcs ck'd by: _____	date: _____	_____

A) Volumes

Inner Lock 335 ft^3
 Outer Lock 147 ft^3

 Total 482 ft^3

B) Performance Requirements

The following dive and ascent rates are taken from "US Navy Divers Handbook". In addition, it is assumed that the outer chamber will be used to transit medical @ 165 fsw/m, dive. 60 fsw/m ascent.

Inner Lock:

Dive, 60 fsw/m, 0 to 165 fsw
 25 fsw/m 0 to 165 fsw
 Ascend, 20 fsw/m @ 60 fsw
 10 fsw/m @ 10 fsw
 1 fsw/m @ 10 fsw

Outer Lock:

Dive, 165 fsw/m, 0 to 165 fsw
 Ascend, 60 fsw/m, 165 fsw to 10 fsw

page ____ of ____

CHESAPEAKE	DIVISION	PROJECT: <u>2 Lock STEEL</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>GORMAN</u>	date: <u>1/2/82</u>	Calculations for: _____
Calcs ck'd by: _____	date: _____	

c) Pressurization

Note: Pressurization and Ascent Rates
 use FG pgm K, "Max Length of Venting Pipe".
 See Crane Tech Bulliten 410.

Inner Lock: Vol = 335 ft³

Header pressure, 350 psig = 364.7 psia

60 fsw/m @ 165 fsw = 72.43 psig = 87.13 psia

$\Delta P = 364.7 - 87.13 = 277.57$ psi

$P' = 364.7$ psia

$\frac{\Delta P}{P'} = \frac{277.57}{364.7} = 0.76$, $Y = 0.76$

USE ↓

pipe dia 1 1/4, (1.38" ID, ft = .022) = 1574' Max Allow Lg
 w @ psig = 0 1, (1.049, .023) = 394'
 976 ft/sec 3/4, (0.824, .025) = 93'

Note: Max Allowable Length is actual length of pipe. For resistance to air flow it is assumed exit, entrance, 2 globe valves, and one 90° elbow every 5 feet.

Outer Lock:

Vol = 147 ft³, 165 fsw @ 165 fsw

$\Delta P = 277.57$

$P' = 364.7$

$\frac{\Delta P}{P'} = 0.76$, $Y = 0.76$

USE ——— = 1 1/4 (1.38", .022) = 1574' Max Allow Lg
 w @ psig = 0 1", (1.049", .023) = 394'
 1176 ft/sec 3/4", (0.824", .025) = 93'
 1/2", (0.622", .027) = —

page ____ of ____

CHESAPEAKE	DIVISION	PROJECT: <u>2 LOCK STEEL</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>Gorman</u>	date: <u>1/2/82</u>	Calculations for: _____
Calcs ck'd by: _____	date: _____	

D) Ascent

Inner Lock: Vol = 335 ft³
 10 fsw/m @ 10', (4.45 psig)
 $\Delta P = 4.45 \text{ psi}$
 $P' = 19.15 \text{ psi}$
 $\frac{\Delta P}{P'} = \frac{4.45}{19.15} = 0.23 \therefore Y = 0.90$

Max Allow Lgt

→ 2 1/2", (2.469, .018) = 1275'
 → 2", (2.067, .019) = 446' ← USE
 1 1/2", (1.61, .021) = 92'

Check

1 fsw/m @ 10' met by observation
 26 fsw/m @ 60 fsw, (26.7 psig)
 $\Delta P = 26.7 \text{ psi}$
 $P' = 41.40 \text{ psig}$
 $\frac{\Delta P}{P'} = \frac{26.7}{41.40} = 0.64, Y = 0.75$

2", (2.067, .019) = 602 ft allowable, \therefore not critical condition

Outer Lock: Vol = 147 ft³
 60 fsw/m @ 10 fsw (4.45 psig)
 $\Delta P = 4.45 \text{ psig}$
 $P' = 19.15 \text{ psig}$ $\frac{\Delta P}{P'} = 0.23, Y = 0.85$

→ 3" (3.066, .018) = 314', Max Allow Lgth.
 → 2 1/2" (2.469, .018) = 78' ← USE
 2" (2.067, .019) = -

page ____ of ____

CHESAPEAKE	DIVISION	PROJECT: <u>2 Lock STEEL</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>Gorman</u>	date: <u>1/2/82</u>	Calculations for: _____
Calcs ck'd by: _____	date: _____	

E) Pressure Reduction Station

1) Main Pressurization

Input Pressure 3000 psig max, 1000 psig min

Output Pressure 400 psig max, 350 psig min

$$\text{Max Flow} = 482 \text{ ft}^3 \times 60 \text{ tsw/m} \times \frac{.445}{14.7}$$

$$= 875 \text{ SCFM}$$

F) Air Storage

Note: From "Diver's Handbook"; Primary Storage sufficient for 2 pressurizations to 165', ventilation requirements to be handled by LP compressor. Secondary, sufficient stored air to conduct the first 30 min. of a treatment table 6A, including 2 excursions of the outer lock to 165' and 1 change of inner lock atmosphere, no continuous ventilation.

Primary 482 ft³ to 165 tsw

$$482 \text{ ft}^3 \times 165 \times \frac{.445}{14.7} = 2408 \text{ Scf} \times 2 = 4416 \text{ Scf}$$

Usable gas (between 3000 and 1000 psi)
Total stored gas = 6624 Scf

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CHESAPEAKE	DIVISION	PROJECT: _____
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: _____	date: _____	Calculations for: <u>o lock steel</u>
Calcs ck'd by: _____	date: _____	

F) Cont'd

Secondary

Dive Chamber to 165 ksw

$$482 \times 165 \times \frac{.445}{14.7} = 2408 \text{ Scf}$$

Two excursions of the outer lock

$$147 \times 165 \times \frac{.445}{14.7} \times 2 = 1469 \text{ scf}$$

One change of inner lock atmosphere during first 30 min. of table 6A

$$335 \times 165 \times \frac{.445}{14.7} = 1673 \text{ scf}$$

$$\text{Secondary Volume} = \underline{5550 \text{ scf}}$$

Usable GAS 3000 psi to 1000 psi

$$\therefore \text{Total stored gas} = \underline{8225 \text{ scf}}$$

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CHESAPEAKE	DIVISION	PROJECT: <u>2 Lock STEEL</u>
Naval Facilities Engineering Command	NDW	Station: _____
DISCIPLINE		E S R: _____ Contract: _____
Calcs made by: <u>Gorman</u>	date: <u>1/2/82</u>	Calculations for: _____
Calcs ck'd by: _____	date: _____	

Gas Farm pipe size - Arbitrary use $\frac{3}{4}"$ to match Pressurization lines

G) O₂ Storage

Adequate from 3000 to 1000 psi to supply one patient thru table six. Assume one patient at rest 1038 SCF O₂.

Supply 6 masks @ 2 ACFM @ 60'

$$12 \text{ ACFM} \times \frac{60 \times .445}{14.7} = 21.7 \text{ SCFM}$$

O₂ Reduction Station:

Input pressure, 3000 to 1000 psig

Output pressure, 400 psig max, 350 psig min

Max Flow 21.7 SCFM.

USE $\frac{3}{8}$ pipe

Vent Rate, Assume no overboard dump, interrupted service =

$$25 \text{ ACFM} \times 6 \text{ masks} = 150 \text{ ACFM}$$

$$@ 60' = 272 \text{ SCF/M. Total}$$

$$186 \text{ SCF/M Inner chamber.}$$

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END

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DTIC